Ammonium Perchlorate

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Concern Grows over Perchlorate Contamination

By Gil Dominguez, AFCEE/PA August 2002

A substance found in the motors that power US strategic and tactical rockets as well as space vehicles has lately become a contaminant of concern as it has made its way into the Nation's drinking water supplies from past operational practices.

Perchlorate is created by the dissolution of ammonium perchlorate (AP), which for the past 50 years has been used by the Department of Defense (DOD) and the National Aeronautics and Space Administration (NASA) as the main ingredient in solid rocket propellant.

The compound is also contained in fireworks, fertilizer, road flares, and airbags inflators, but according to US Environmental Protection Agency (EPA) reports, about 90 percent of the approximately 20 million pounds of AP produced each year goes into solid rocket fuel for DOD missiles and the NASA space shuttles.

Perchlorate has been described as an extremely soluble and highly mobile contaminant that can exist for decades in ground and surface water. Because of these features, perchlorate migrates faster and farther than many other contaminants, officials said.

The contaminant has been detected in ground water and drinking water wells across the country, in California, Nevada, Massachusetts, Maryland, and Utah.

DOD facilities where perchlorate is currently being investigated include the Aberdeen Proving Grounds, MD.; Edwards AFB, CA; Longhorn Army Ammunition Plant, Karnack, TX; Massachusetts Military Reservation, Cape Cod, MA; and the Naval Weapons Industrial Reserve Plant McGregor, Waco, TX.

The US Air Force is working with the federal contractor Thiokol Corporation, the world's leading producer of solid rocket motors, to optimize a process developed by the Air Force Research Laboratory that minimizes the amount of perchlorate that finds its way into the environment from production activities.

Perchlorate troubles the environmental community in general, and regulators in particular, because it has been used medically to treat hyperthyroidism, and is therefore perceived as a potential health threat. According to the US EPA, even at very low levels, perchlorate can disrupt the normal functioning of the thyroid gland, the organ that produces the hormones that control metabolism, growth, and development. The agency believes that infants and children are particularly at risk from low-level exposure.

Perchlorate first became an issue in 1997 when a new analytical detection method allowed it to be detected at levels down to 4 ppb (parts per billion). As awareness of perchlorate contamination has increased, so has the drive to do something about the problem. In 1998, the Air Force initiated a process in which a number of organizations joined forces to form the Interagency Perchlorate Steering Committee, or IPSC.

AFCEE is a member of the committee as are representatives from other DOD agencies, the US EPA, state, and local regulators and Native American tribes.

Erica Becvar of AFCEE's Technology Transfer Division said the IPSC's purpose was "to ensure that credible science led to credible decisions" which, in turn, would lead to a maximum containment level "that would be totally indicative of the risk associated with perchlorate in the environment." As established by the US EPA, the maximum contaminant level, or MCL, is the maximum concentration of a chemical allowable in public drinking water systems.

Two years ago, AFCEE was asked to lead the IPSC's treatment technology efforts. Since then, the center's role, said Becvar, had been to "monitor technologies that can effectively treat perchlorate in soils and groundwater. There are other issues, such as perchlorate in drinking water and air, but we're concentrating on soil and groundwater."

AFCEE, she added, is not as yet directly sponsoring treatment technology projects. Instead, the Center is working the issue with the Services and two DOD initiatives, the Strategic Environmental Research and Development Program (SERDP) and the Environmental Security Technology Certification Program (ESTCP). Collectively, the Defense Department has spent in excess of $24 million to develop innovative perchlorate treatment technologies.

Becvar noted that there are two technologies that look especially promising and are being applied full-scale. They are the ion exchange system and anaerobic bioreactors. Both of these are

ex-situ forms of treatment, meaning that they take place above ground, away from the original contamination site.

In the ion exchange system used at Edwards AFB, CA, contaminated water was pumped through a resin bed containing millions of beads that cause the perchlorate molecule to undergo a chemical transformation, converting it into a harmless chloride ion. Officials said that ion exchange does not physically destroy the perchlorate; rather, it concentrates it into a perchlorate-rich brine that must then be disposed of, thus incurring additional costs. However, the process has been approved by California for general drinking water applications.

A bioreactor is an aboveground reactor vessel into which contaminated water is pumped. Unlike conventional bioreactors that must have oxygen, the bioreactors used to treat perchlorate operate under anaerobic, or oxygen-free conditions. Microorganisms that have been cultivated in the reactor then remove the perchlorate by consuming it as a food source.

Bioreactors are used at DOD and propulsion manufacturer facilities that generate perchlorate waste streams or have perchlorate-contaminated groundwater. The Air Force Research Laboratory at Tyndall AFB, FL, developed bioreactor systems to treat process groundwater containing very high perchlorate levels. Since 1997, a system based on the AFRL design has been treating process wastewater from rocket motor production at the Thiokol facility near Brigham City, UT. The first DOD facility to install a functional bioreactor to treat perchlorate-contaminated groundwater was the Longhorn Army Ammunition Plant.

"One of the companies that is treating perchlorate with a bioreactor has received conditional approval from the state (of California) to use it for drinking water purpose," said Becvar. "It has not been applied, but bioreactors are slowly becoming more accepted for treatment of source water for distribution as part of public water supplies. That's a first. It's a big thing."

In addition to these two main technologies, Becvar said "We're also looking into soil composting, permeable reactive barriers, natural attenuation, and injecting oxygen into the ground to stimulate degradation," she said. "These are technologies that work with chlorinated solvents and with petroleum hydrocarbons, and we believe – although they haven't been applied to any great extent – that with a little bit of tweaking they can address perchlorate as well."

Becvar stated that while there currently is no regulatory requirement for bases to sample for perchlorate, states and US EPA regions are pressing military installations to do so, and she believes that it is just a matter of time before DOD makes sampling mandatory to meet the regulatory requirement.

"Some bases are going to find it (perchlorate) and will have to do something about it," Becvar said. "Just as in the past we have helped our bases identify treatment technologies for chlorinated solvents, fuels and so forth, we'll be doing the same in the future for perchlorate."

Probably the main stumbling block to sampling is the lack of an established MCL for the contaminant. State-issued recommended action levels, while not regulatory drivers per se, put tremendous pressure on installations to sample for perchlorate, and action levels typically range anywhere from 4 to 32 ppb, with some as low as 1 ppb.

The action level is the amount of perchlorate water must contain before purveyors are required to report it to state regulators. The water system size (*i.e.*, the number of people or households served) is a factor in determining if reporting is necessary. One ppb represents one molecule of perchlorate for a billion molecules of water, roughly equal to a drop of water in an Olympic-size pool. Olympic pools can hold up to a million gallons of water.

Becvar stressed that while perchlorate is treatable, a formal regulatory standard is needed to establish at what levels the presence of perchlorate is acceptable, taking in to account any possible risks to human health.

"There is an analytical method right now, approved by the EPA, that has a reporting limit of 4 ppb," she said. "Values reported as being less than 4 ppb are derived statistically, and indicate only the unquantified presence of the substance. Unfortunately, laboratories are reporting these values as an absolute number."

Becvar noted that while the US EPA had considered a perchlorate MCL of 32 ppb, the agency is now revising that number and looking at an oral reference dose, or RfD, that would eventually lead to a MCL of 1 ppb. The RfD is an estimate of how likely it is that there would be a risk to people if they were exposed to a contaminant every day of their lives.

Lower requirements, of course, mean that environmental managers face a tougher and more costly task when treating perchlorate. As Becvar explained, "The lower the requirements go, the greater amount of water that has to be treated. So, that increases the cost because you have to install a bigger system. If you're doing pump-and-treat, you'll have to put in more wells and run the system longer in order to treat the huge volume of water at that level."

In addition, the more extensive the contamination means the more expensive the cleanup. There is one site, Becvar said, where the contamination plume measures four miles long by one mile wide.

Technology Transfer's job is to search for treatment systems that might prove less costly yet work just as well as methods now in operation. So Becvar and her division colleagues continue to analyze promising cleanup methods and meet with others working in the perchlorate initiative. For example, Technology Transfer personnel are working with the Interstate Technology Regulatory Council (ITRC), a coalition of 42 states working with industry, federal agencies, and other interested parties to achieve acceptance of new environmental technologies. Together, the ITRC and Technology Transfer personnel will be developing a treatment technology overview that they will make available to everyone involved in or concerned about the perchlorate issue.

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